

# *Comparative Study of Reticle Electrical Static Discharge under N<sub>2</sub> purge and 40% Relative Humidity Ambient*

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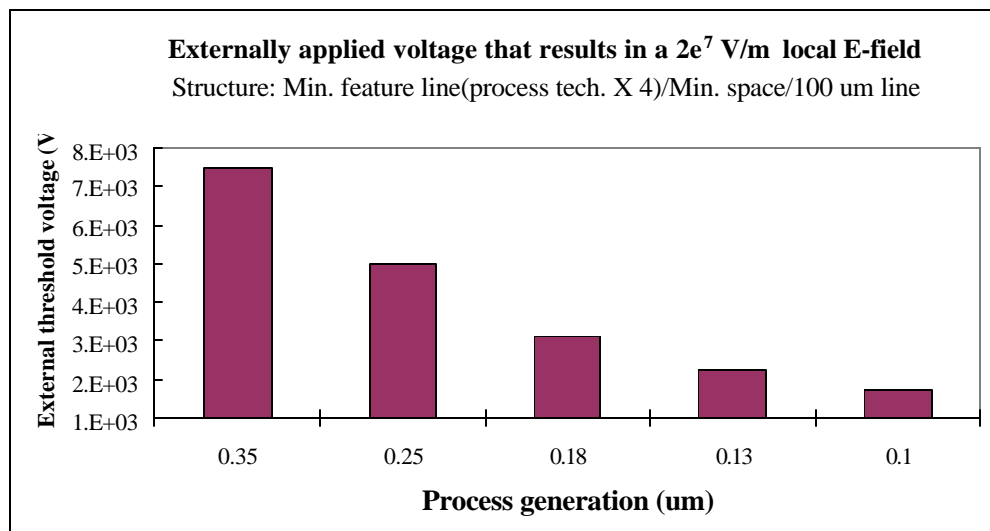
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# Introduction

- ESD risk will increase as technology node move toward 0.1 um generation



**Simulation Results:**  
voltage required to generate  $2e^7$  V/m local E-field at 0.1 um technology is 1/3 of 0.18 um generation

- Reticle for 157-nm lithography is expected to be handled under inert gas purged dry environment in which relative humidity  $\rightarrow$  0% ( $< 1$  ppm  $H_2O$ )
- As relative humidity  $\rightarrow$  0%, ESD risk will increase because of 2X-20X increase in electrostatic charge generation/accumulation

# *Objective*

- Evaluate ESD risk in inert gas purged dry environment
  - Charge dissipation, threshold voltage, and ESD damage
- Explore possible technical solution
  - Ionization (global and local)

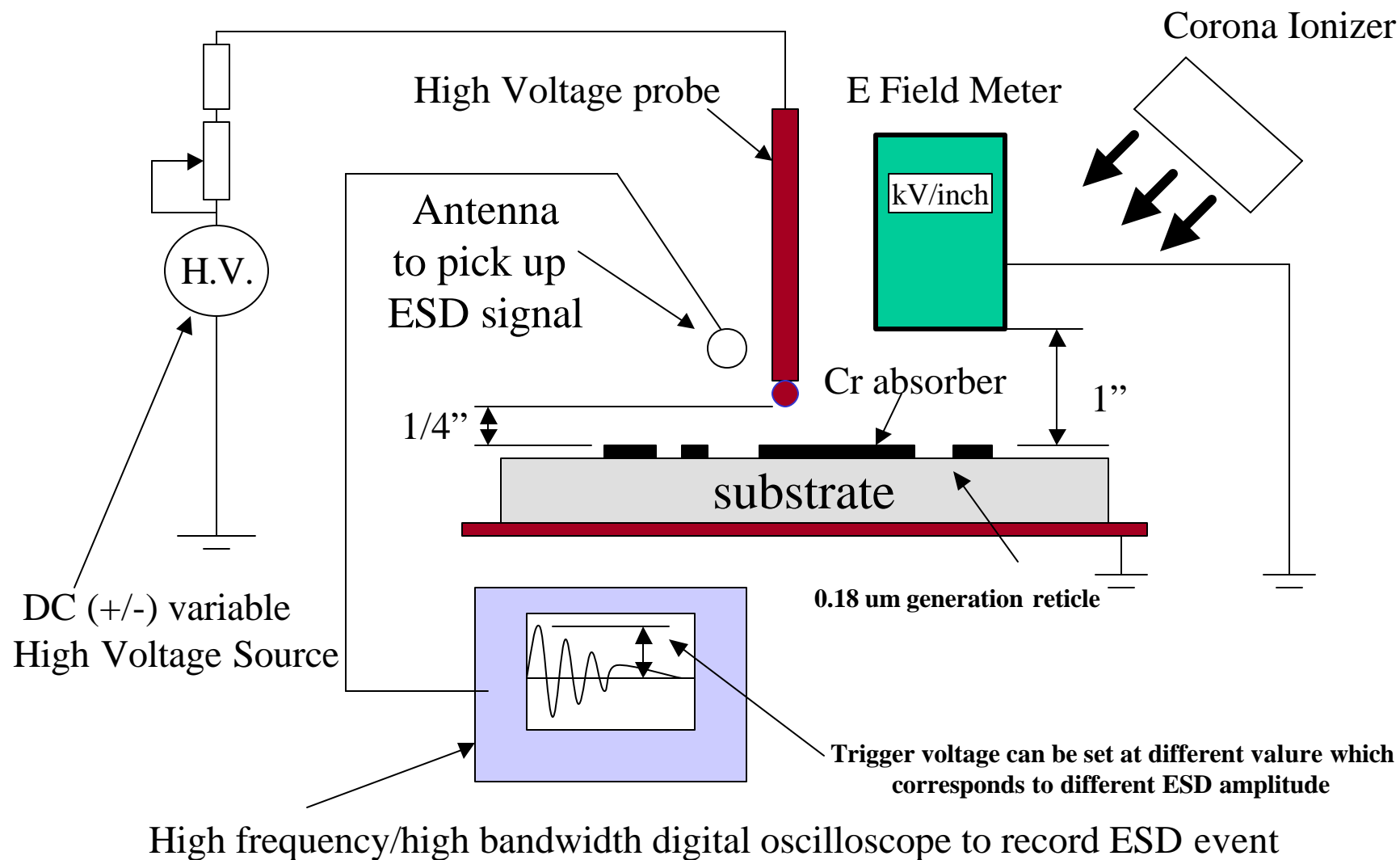
# Outline

- Experimental set-up and experimental methodology
- Comparative study of charge dissipation under N<sub>2</sub> purge, 40% relative humidity, and N<sub>2</sub> purge with ionization
- Comparative study of threshold voltages under N<sub>2</sub> purge, 40% relative humidity, and N<sub>2</sub> purge ionization
- Comparative ESD damage study for reticle under N<sub>2</sub> purge and 40% relative humidity
- Localized ionization with Po<sub>210</sub> for charge dissipation under pellicle: experimental results on its effectiveness.
- Summary and remark

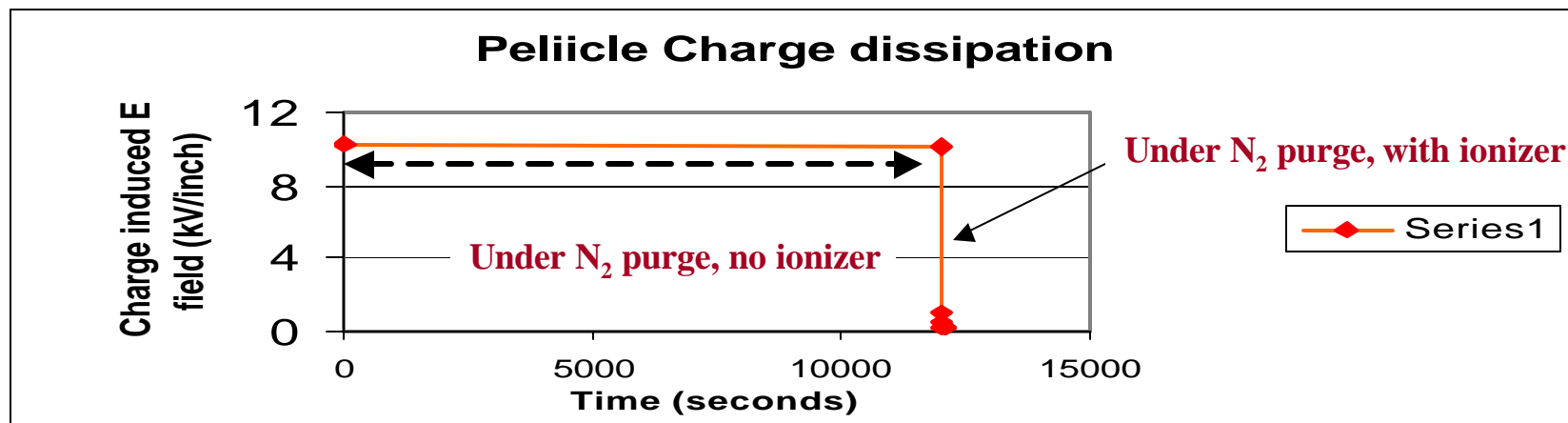
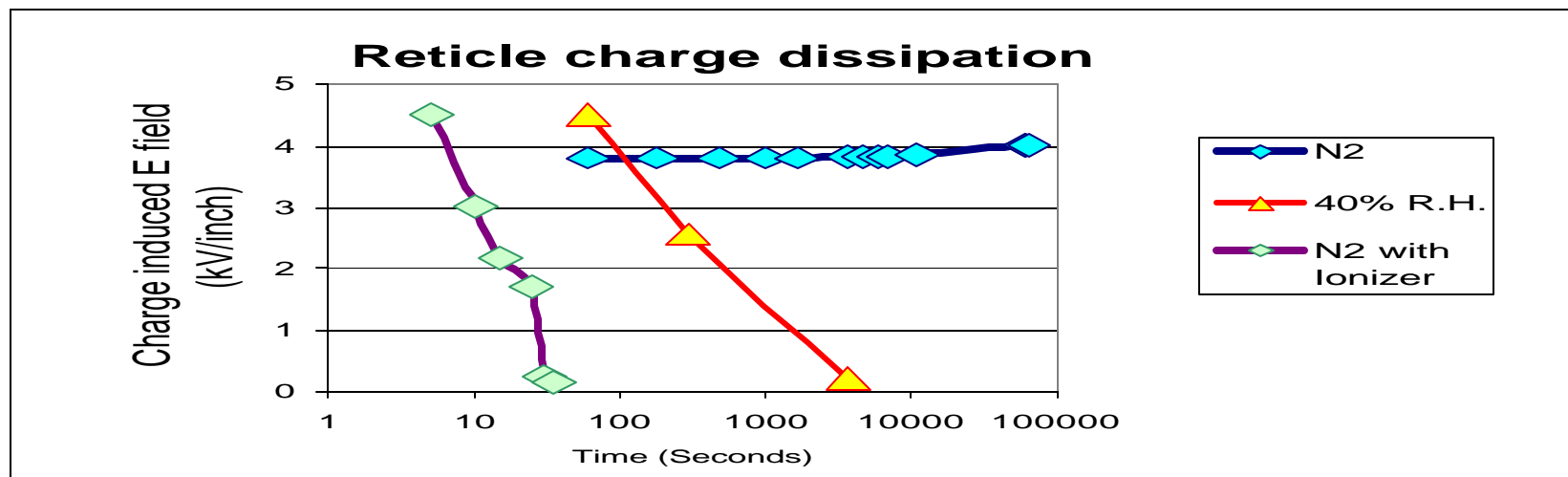
# *Equipment Set-Up in this ESD Study*

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## *ESD Set-Up Block Diagram to Illustrate Test Methodology*

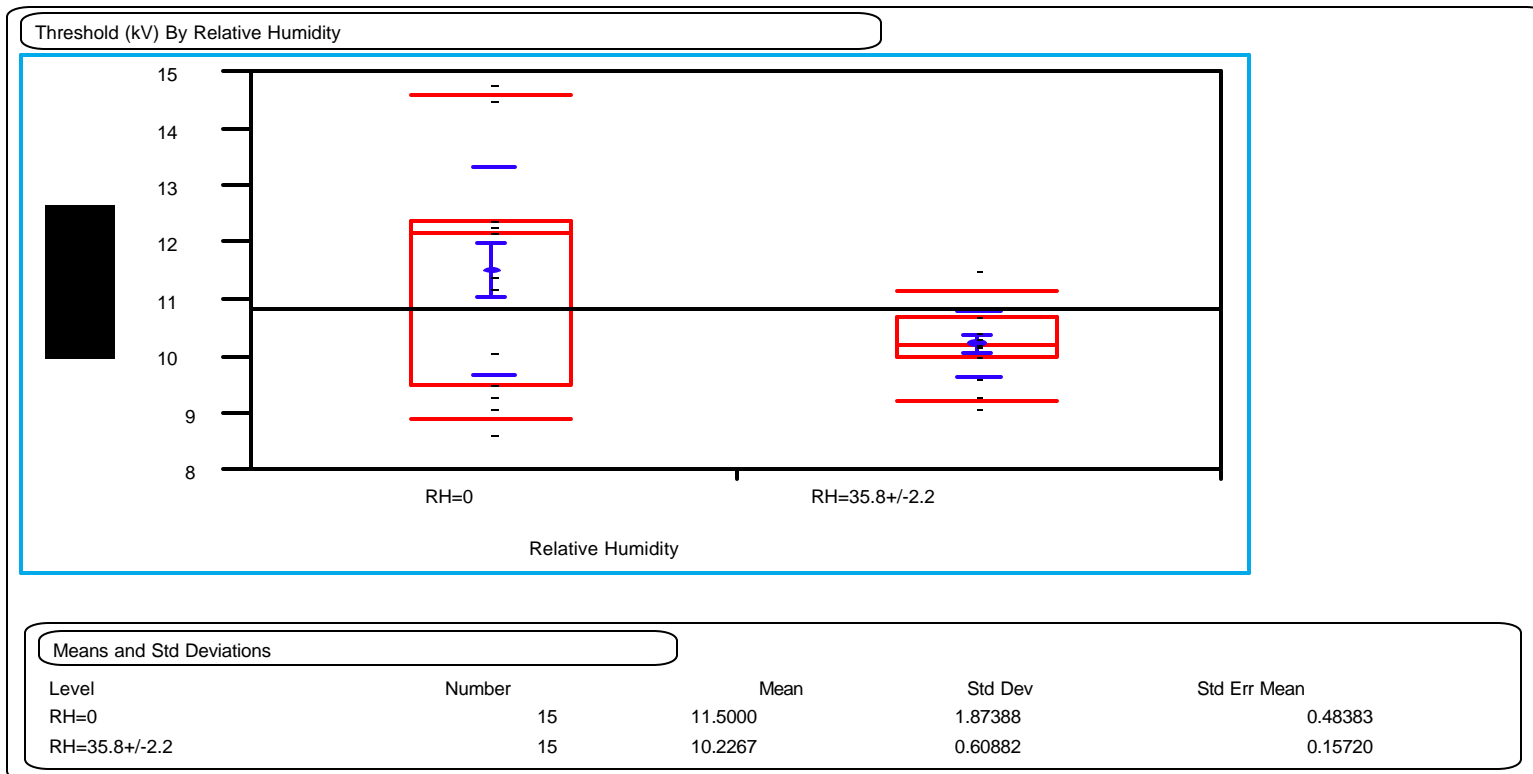


## Comparison of charge dissipation under $N_2$ purge, $N_2$ purge with ionizer and, Air with 40% RH



Charge can not be dissipated under  $N_2$  purged environment  
but can be dissipated effectively in  $N_2$  purged environment with ionizer

## Comparison of voltage required to trigger ESD under $N_2$ purge and air with 40% R.H.

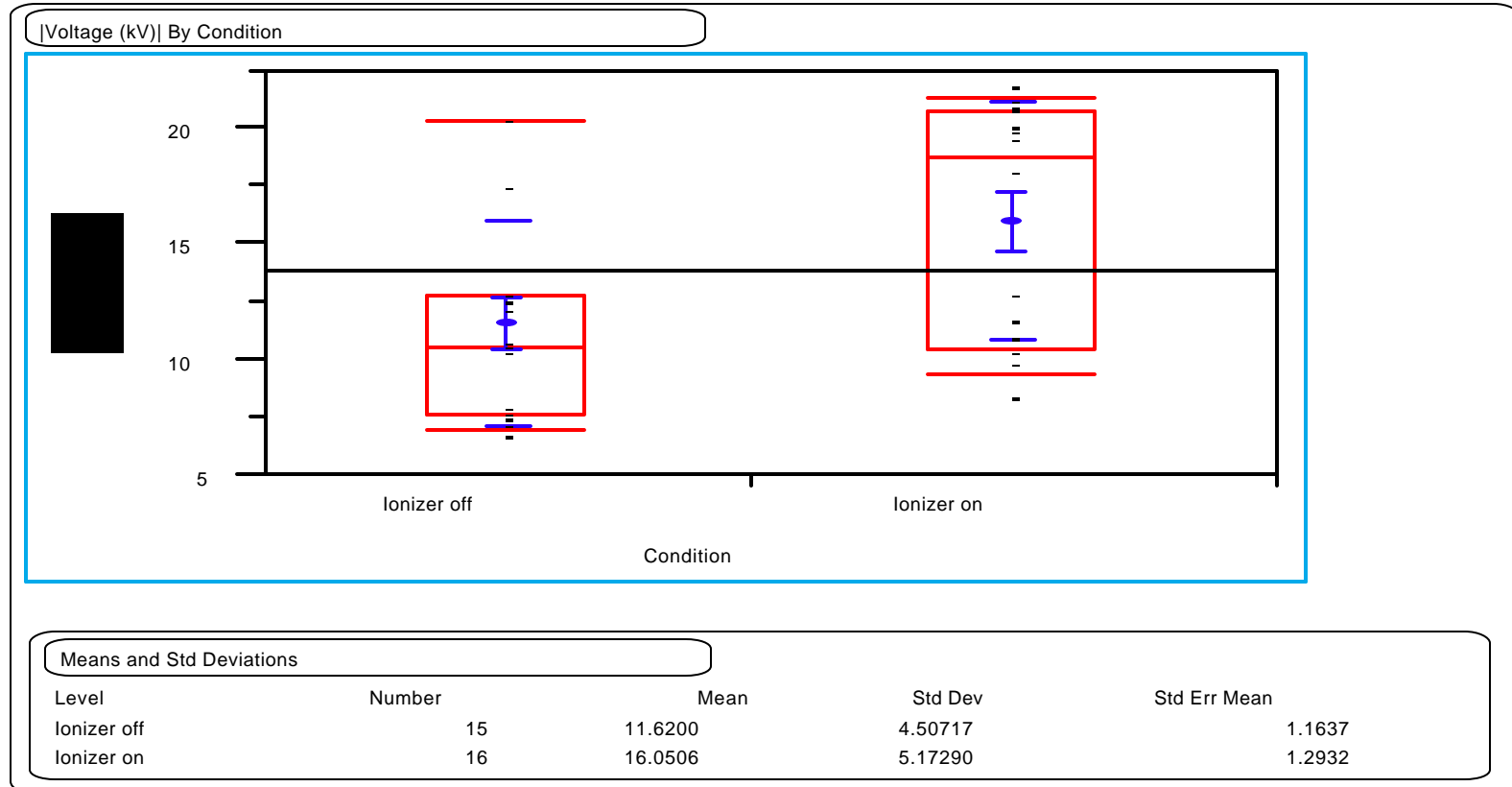


Voltage required to trigger ESD is equivalent

**Note: Oscilloscope set trigger voltage =32 mV, tested at positive induced voltage**



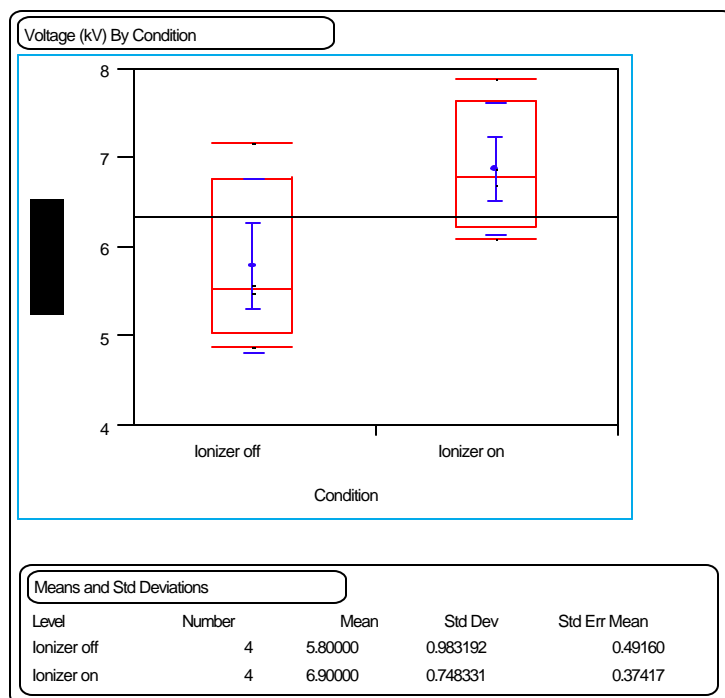
## Comparison of voltage required to trigger ESD with and without ionizer (under $N_2$ purge)



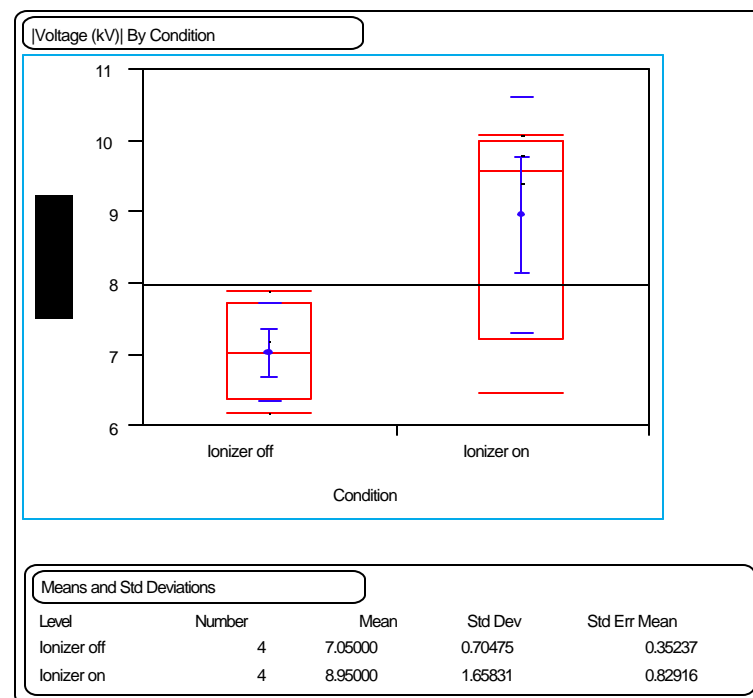
Ionizer make it requires more voltage to trigger ESD

*Note: Oscilloscope set trigger voltage =32 mV , tested at neagive induced voltage*

# Comparison of voltage required to trigger ESD with and without ionizer (under $N_2$ purge) @ reduced ESD Oscilloscope trigger voltage set-up



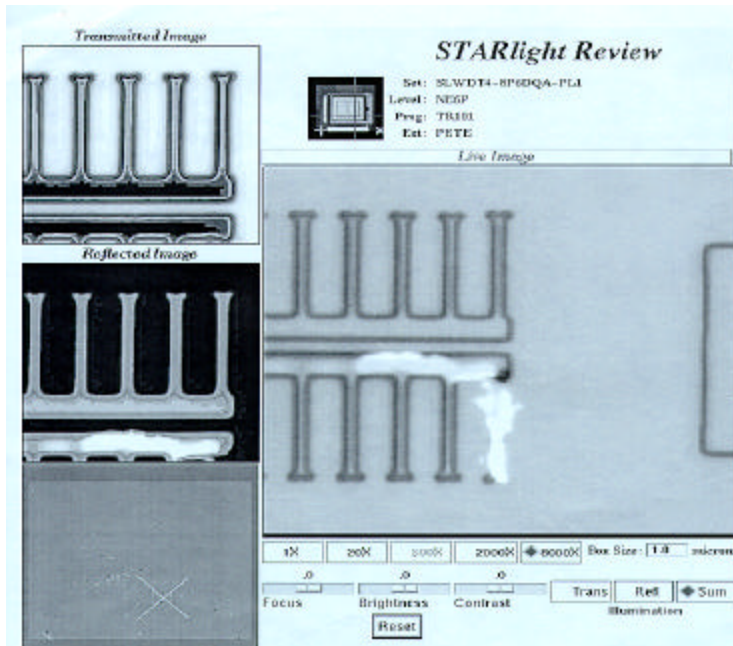
Tested at positive induced voltage  
Oscilloscope trigger voltage = 6 mV



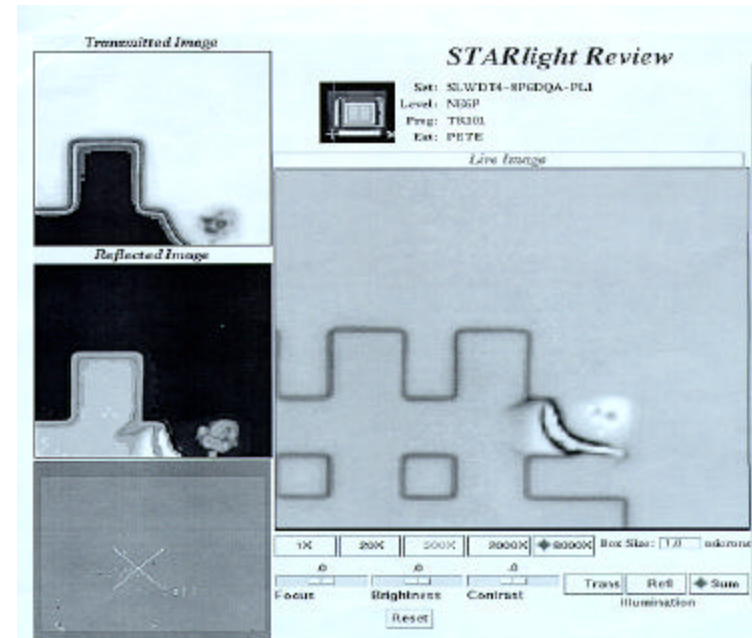
Tested at negative induced voltage  
Oscilloscope trigger voltage = 6 mV

Ionization make it more difficult to trigger ESD: need higher voltage

## *ESD induced damages under $N_2$ and air with 40% RH*



Under 40% RH



Under  $N_2$  Purge

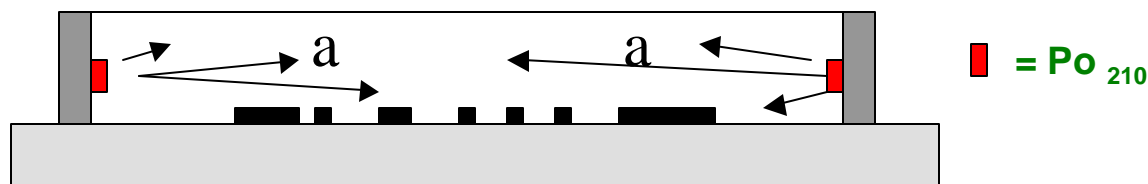
**Damage signature is similar: from corrosion on AR layers to missing Cr layer**

# *Po<sub>210</sub> Alpha emitter for localized ionization*

## Why localized ionization is needed?

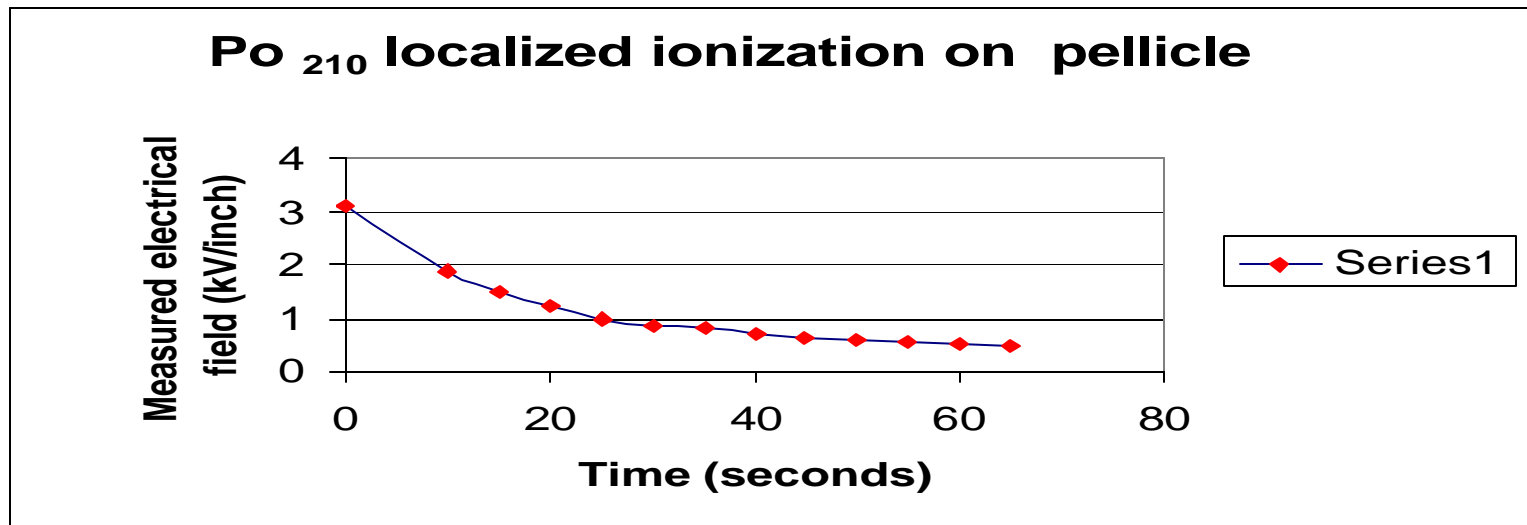
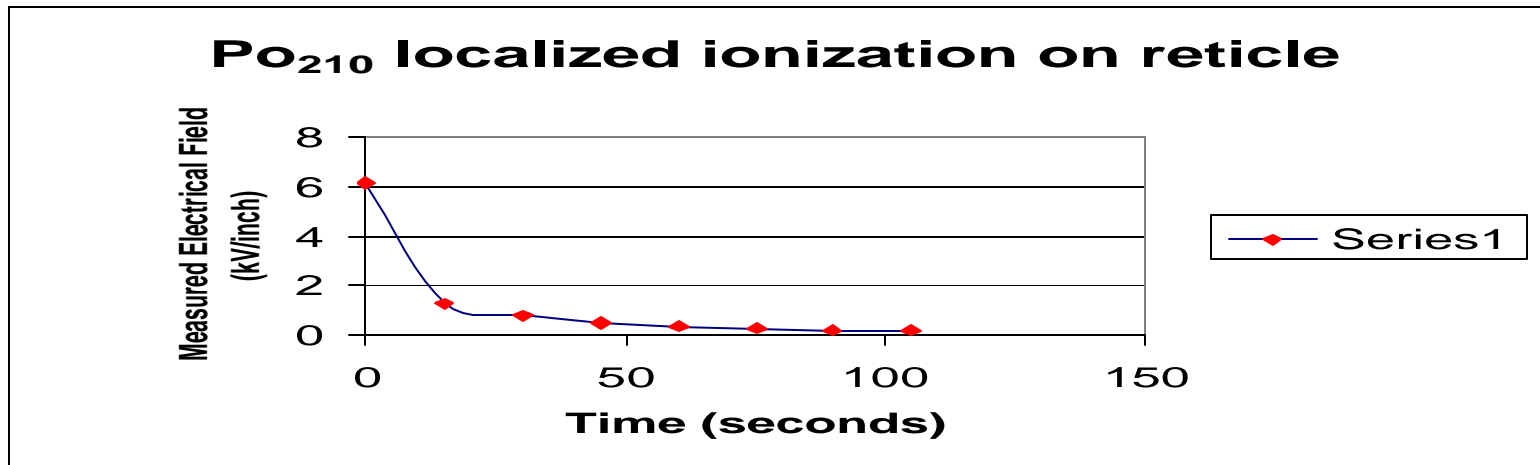
- Corona ionizer can not effectively ionize space between reticle and pellicle
- High voltage from outside of pellicle can charge reticle through pellicle
- Purge between reticle and pellicle can generate triboelectrical charge on reticle
- Reticle during shipping and handling under N<sub>2</sub> may need reliable constant ionization

## The concept of Po<sub>210</sub> ionization



Note: Po<sub>210</sub> alpha emitter ionization has been used in industry where high level of ESD protection is required, e.g. hard disk driver manufacture

## Result: Po<sub>210</sub> Alpha Emitter Localized ionization



Po<sub>210</sub> alpha emitter ionization is as effective as corona ionization

# Summary

- Ionization can effectively dissipate charge generated on reticle and pellicle
- $\text{Po}_{210}$  can be used for localized ionization between reticle and pellicle
- Voltage required to trigger ESD is equivalent for  $\text{N}_2$  purged environment and for ambient with 40% R.H.
- Ionization make the voltage required to trigger ESD higher than that without ionization
- ESD damage signature under  $\text{N}_2$  purge and ambient with 40% R.H. appears to be similar

## Final remark

Other type of ionization should be explored. Soft X-ray and VUV radiation ( under  $\text{N}_2$  purge) can provide effective ionization with the advantage of no particle generation and no need for localized ionization

## Acknowledgement

Mark Sanesi of Sanesi Associates for assistance with some of the tests.  
Thanks to Dr. Larry Levit of Ion System for useful discussions